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Publication Title:

ECHO CANCELLER WITH ADAPTIVE VOICE SWITCH ATTENUATION

Abstract:

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This invention relates to an echo canceller (EC) such as for use in a full duplex radio. The echo canceller comprises: an output path (10) for outputting desired signals; an input path (12) for receiving desired signals together with undesired echos from the output path; an adaptive filter (14) for filtering signals on the input path; measuring means (18) for measuring echo attenuation by the adaptive filter; a variable attenuator (15) for attenuating signals on the input path; control means (16) for controlling the variable attenuator to provide a degree of attenuation dependent on the difference between attenuation measured by the measuring means and a predetermined desired attenuation. The echo canceller is particularly useful in any system having large transmission delays like GSM cellular radio telephone system.

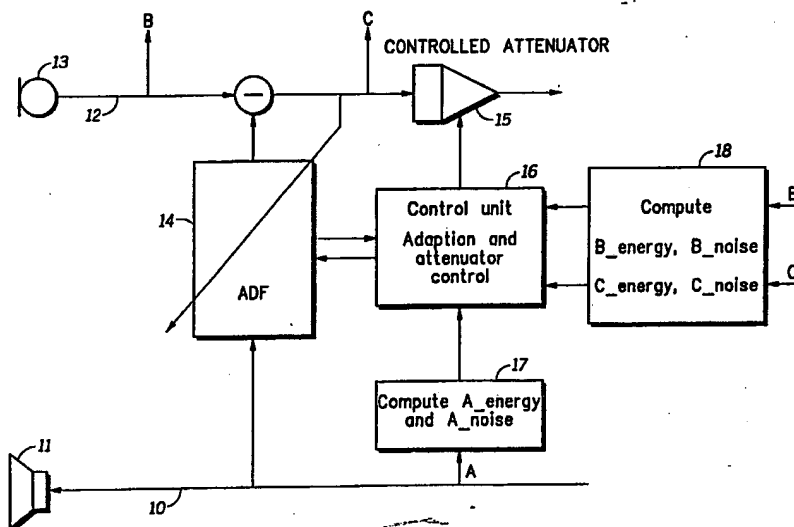
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## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<b>(21) International Application Number:</b> PCT/EP91/01130 <b>(22) International Filing Date:</b> 19 June 1991 (19.06.91) <b>(30) Priority data:</b> 9013751.4                      20 June 1990 (20.06.90)                      GB <b>(71) Applicant (for all designated States except US):</b> MOTOROLA, INC. [US/US]; 1303 East Algonquin Road, Schaumburg, IL 60196 (US). <b>(72) Inventors; and</b> <b>(75) Inventors/Applicants (for US only) :</b> THRANE, Morten [DK/DK]; Skovstykke 17, DK-2830 Virum (DK). PETERSEN, Kim, Tilgaard [DK/DK]; Godthabsvej 50 4tv, DK-2000 Frederiksberg (DK).		<b>(74) Agent:</b> DUNLOP, Hugh, Christopher; Motorola, European Intellectual Property Operations, Jays Close, Viables Industrial Estate, Basingstoke, Hants RG22 4PD (GB).  <b>(81) Designated States:</b> AT (European patent), AU, BB, BE (European patent), BF (OAPI patent), BG, BJ (OAPI patent), BR, CA, CF (OAPI patent), CG (OAPI patent), CH (European patent), CI (OAPI patent), CM (OAPI patent), DE (European patent), DK (European patent), ES (European patent), FI, FR (European patent), GA (OAPI patent), GB (European patent), GN (OAPI patent), GR (European patent), HU, IT (European patent), JP, KP, KR, LK, LU (European patent), MC, MG, ML (OAPI patent), MR (OAPI patent), MW, NL (European patent), NO, PL, RO, SD, SE (European patent), SN (OAPI patent), SU, TD (OAPI patent), TG (OAPI patent), US.  <b>Published</b> <i>With international search report.</i>

**(54) Title:** ECHO CANCELLER WITH ADAPTIVE VOICE SWITCH ATTENUATION**(57) Abstract****ECHOCANCELLER WITH AVSA**

This invention relates to an echo canceller (EC) such as for use in a full duplex radio. The echo canceller comprises: an output path (10) for outputting desired signals; an input path (12) for receiving desired signals together with undesired echos from the output path; an adaptive filter (14) for filtering signals on the input path; measuring means (18) for measuring echo attenuation by the adaptive filter; a variable attenuator (15) for attenuating signals on the input path; control means (16) for controlling the variable attenuator to provide a degree of attenuation dependent on the difference between attenuation measured by the measuring means and a predetermined desired attenuation. The echo canceller is particularly useful in any system having large transmission delays like GSM cellular radio telephone system.

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ECHO CANCELLER WITH ADAPTIVE VOICE SWITCH ATTENUATIONBackground of the Invention

5        This invention relates to an echo canceller (EC) such as for use in a full duplex radio. The echo canceller is particularly useful in any system having large transmission delays like the GSM system.

10    Summary of the Prior Art

      A conventional echo canceller calculates a pseudo-echo by convolution (filter operation) with the received signal and the tap coefficients of the adaptive filter (ADF). The  
15    ADF will converge to an estimate of the echopath. This pseudo-echo is subtracted from the actual echo, thereby cancelling the echo. The ADF is usually a N tap FIR filter, where  $N \cdot T$  equals the duration of the echo and T denotes the time between samples. In order to eliminate the echo quickly,  
20    the ADF must converge to the actual impulse response.

      The GSM cellular radio system calls for standards in cancellation of echos not reached in previous systems. The echopath can either be of acoustic nature caused by the coupling between a microphone and loudspeaker in handsfree  
25    operation or it can be of electrical nature due to imperfections in the 4 to 2 wire hybrids in the fixed network. Due to the inherent transmission delay in GSM (total loop delay around 200 msec) the typical Echo Return Loss (ERL) required will be 56 dB compared to a typical ERL  
30    of 20 dB in conventional cellular systems. As the echo tends to become more annoying as the transmission delay increases, the performance of the EC unit is very important to obtain high conversation quality.

      An echo canceller designed to meet the requirements  
35    of the GSM cellular radio system is described in UK Patent Application No. 9000525.7, filed on 10th January 1990.

      The convergence speed of the ADF is often too low to meet the required performance.

Summary of the Invention

According to the present invention, an echo canceller is  
5 provided comprising:

an adaptive filter, measuring means for measuring echo  
attenuation by the adaptive filter, a variable attenuator and  
control means for controlling the variable attenuator to  
provide a degree of attenuation dependent on the difference  
10 between attenuation measured by the measuring means and a  
predetermined desired attenuation.

Preferably the attenuator provides up to half of the  
total desired attenuation. Preferably the attenuator  
provides no more than 10 to 15dB of maximum total  
15 attenuation.

It is preferred that the variable attenuator provides  
low or negligible attenuation when there is at less than 3 dB  
of signal on the output path (A energy) above noise level on  
that path.

20 Preferably the attenuator responds to a signal on the  
input path, (B energy) to provide a relatively low level of  
attenuation at a high level of such a signal and higher  
attenuation at a lower level of such a signal. Preferably,  
on opening in response to a signal on the input path (b  
25 energy) the attenuator opens at a controlled rate. Such a  
rate may be one millisecond for full opening.

At a low level of input signal (B energy) and a low  
level of output signal (A energy) the attenuator may be  
arranged to open slowly - eg taking 200 milliseconds to open  
30 when there is no B energy and when A energy is less than 3 dB  
over noise.

The invention has the effect of compensating the slow  
convergence of the ADF by introducing a voice switch mode  
whenever the performance of the ADF is insufficient. A  
35 specific embodiment will be described in which the voice  
switch does not suffer from problems of speech clipping and  
background noise switching.

Brief Description of the Drawings

Fig. 1 shows an echocanceller with adaptive voice switch attenuation in accordance with the invention.

5 Fig. 2 shows a flow diagram of the ERLE computation routine.

Fig. 3 shows a flow diagram of the voice attenuation routine.

10 Description of the Preferred Embodiment

Referring to Fig. 1, there is shown an output power 10 having a loudspeaker 11 and an input path 12 having a microphone 13. The loudspeaker and microphone are typically  
15 mounted on the interior of a vehicle. The echocanceller comprises a fullband adaptive filter 14, the details of which are known in the art (reference is made, for example, to Y.Itoh et al, "An acoustic echo canceller for teleconference" proceedings of ICC-85,1985 pp1498-1502) or a sub-band  
20 adaptive filter. The echocanceller further comprises a variable attenuator 15 and a control unit 16 having computation means 17 and 18. Measurements of energy on the input path are taken at points B and C before and after adaptive filtering and these are entered into computation  
25 means 18.

The computation means 18 in effect measures the attenuation achieved by the ADF 14. The control unit 16 controls the attenuator 15 to augment the measured attenuation by the necessary amount to bring the total  
30 attenuation to 30 dB. The measured attenuation is only augmented when there is energy on the output path 10. This is measured by computation means 17.

The computation of the ADF attenuation is described in Fig. 2. Computation means 18 computes the ERLE factor (which  
35 is an estimate of the current echocanceller performance and is computed by the formula:

$$\text{ERLE} = (\text{C energy} - \text{C noise}) / (\text{B energy} - \text{C noise})$$

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The flow diagram of Fig. 2 shows an example of an ERLE factor computation, although this can be computed in various ways. Referring to that figure, step 21 determines whether the ADF has, in fact, provided any attenuation, and if so, step 22 computes the factor ERLE'. In step 23, no further action is taken if ERLE' is greater than 50 dB. Otherwise, ERLE' is filtered in a two-order IIR filter, with  $f_c = 0.1$  hz (step 24). The output of this filter is ERLE. In steps 25, 26 and 27, ERLE is decremented or incremented by a predetermined amount, according to whether it is greater or less than ERLE' respectively. Provided ERLE is greater than 0 this provides the ERLE factor. If ERLE is less than 0, it is set to 0 in step 29.

After the ERLE computation routine of Fig. 2, the control unit 16 performs a set voice attenuation routine, described in Fig. 3. If ERLE is greater than 30 dB, as determined by step 31, no additional attenuation is required and step 32 sets the attenuation of the attenuator 15 at a minimum limit, which is 3 dB. Otherwise, if ERLE is not greater than 30 dB, step 33 sets the attenuation at 30 dB minus ERLE. If the maximum attenuation as set in step 33 is greater than 15 dB (step 34), that maximum attenuation is capped at 15 dB in step 35. Steps 34 and 35 ensure that the attenuator 15 does not in fact provide more than 15 dB. Steps 36 and 37 set a lower limit on the attenuation of the attenuator 15 at 3 dB.

The B energy and C energy measurements are absolute values of samples at point B and C in Fig. 1, respectively, filtered through a two-order IIR filter, with cutoff frequency 50 Hz. The B energy and C energy values represent the summation of speech and noise at these respective points and will follow the envelope of speech on the input path 12. Values for C noise are absolute values of samples at point c, filtered through a two-order IIR filter with cutoff frequency 0.1 hz. Thus the measurement of C noise is an estimate of the noise floor at point C.

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The voice switch attenuation of the attenuator 15 is set to keep the total attenuation/cancellation at the required value, ie 30 dB, and the voice controller attenuator (or voice switch) will in this particular case be limited by 3 and 15 dB, although other limits for this range could be chosen. Thus the attenuation can vary continuously between 3 and 15 dB, thereby avoiding any annoying effect of changing from pure ADF attenuation to a voice switched mode. Such annoying effect could be experienced if the circuit switched between pure ADF at ERLE factors greater than 30dB and pure switched mode at ERLE factors below 30dB.

Continuously varying attenuation is achieved because the ERLE monitor routine is run in real time, measuring the desired attenuation for each sample of digital speech - i.e. every 125 $\mu$ s. Preferably, the energy measurement used for calculating ERLE is down-converted 20 times, effectively providing a calculation every 20 samples.

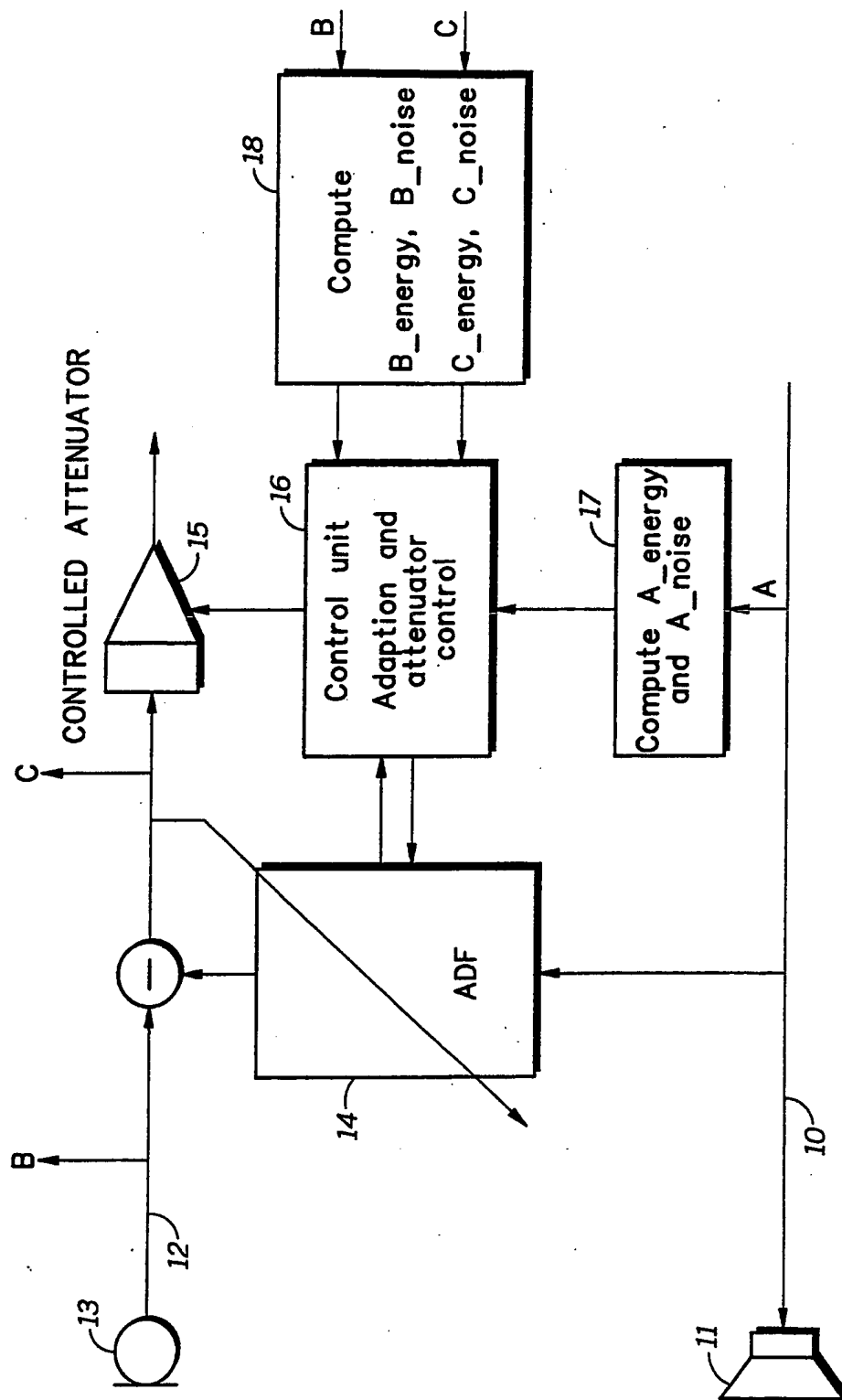
CLAIMS

1. An echocanceller comprising:  
an output path (12) for outputting desired signals;  
5 an input path (10) for receiving desired signals  
together with undesired echos from the output path; and  
an adaptive filter (14) for filtering signals on the  
input path characterized by:  
measuring means (18) for measuring echo attenuation by  
10 the adaptive filter;  
a variable attenuator (15) for attenuating signals on  
the input path;  
control means (16) for controlling the variable  
attenuator to provide a degree of attenuation dependent on  
15 the difference between attenuation measured by the measuring  
means and a predetermined desired attenuation.
2. An echocanceller according to claim 1, further  
comprising:  
20 means (17) for measuring energy on the output path; and  
means for controlling the variable attenuator to provide  
greater attenuation of signals on the input path at a high  
level of energy on the output path than at a low level.
- 25 3. An echocanceller according to claim 1 or 2, wherein no  
more than 15 dB of total attenuation is provided by the  
attenuator.
4. An echocanceller according to claim 1 or 2, wherein the  
30 variable attenuator provides low or negligible attenuation  
when there is at least a predetermined level of signal on the  
output path above noise level on that path.
5. An echocanceller according to any one of the preceding  
35 claims, wherein the attenuator responds to signals on the  
input path (B energy) to provide a relatively low level of  
attenuation at a high level of such a signal and higher  
attenuation at a lower level of such a signal.

6. An echocanceller according to any one of the preceding  
claims, wherein the attenuator is arranged to open at a  
controlled rate in response to a signal on the input path (B  
5 energy).

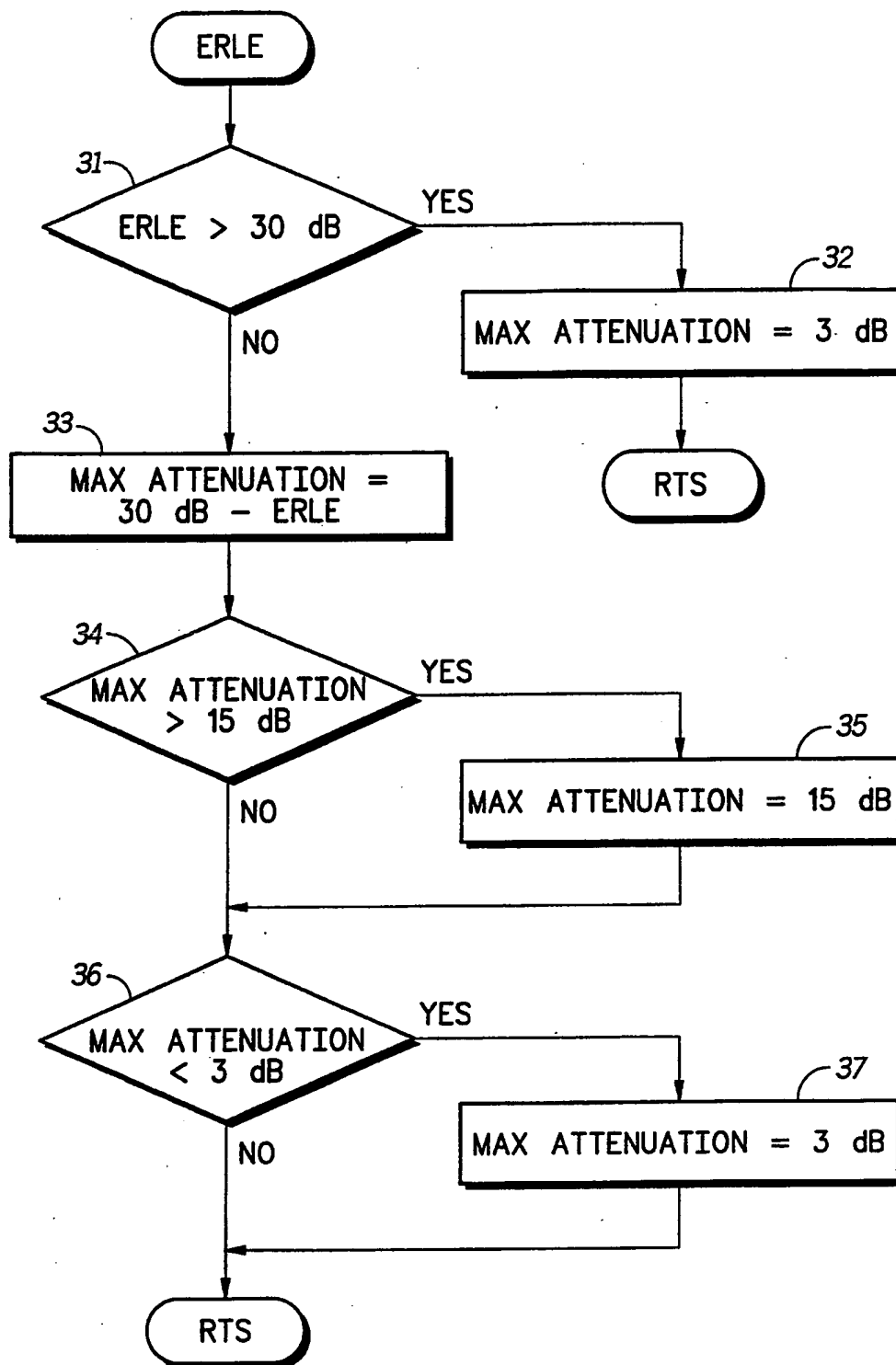
7. An echocanceller according to claim 6 wherein said rate  
is a fast rate and wherein the attenuator is arranged to open  
at a slow rate at a low level of input signal (B energy) and  
10 a low level of output signal (A energy).

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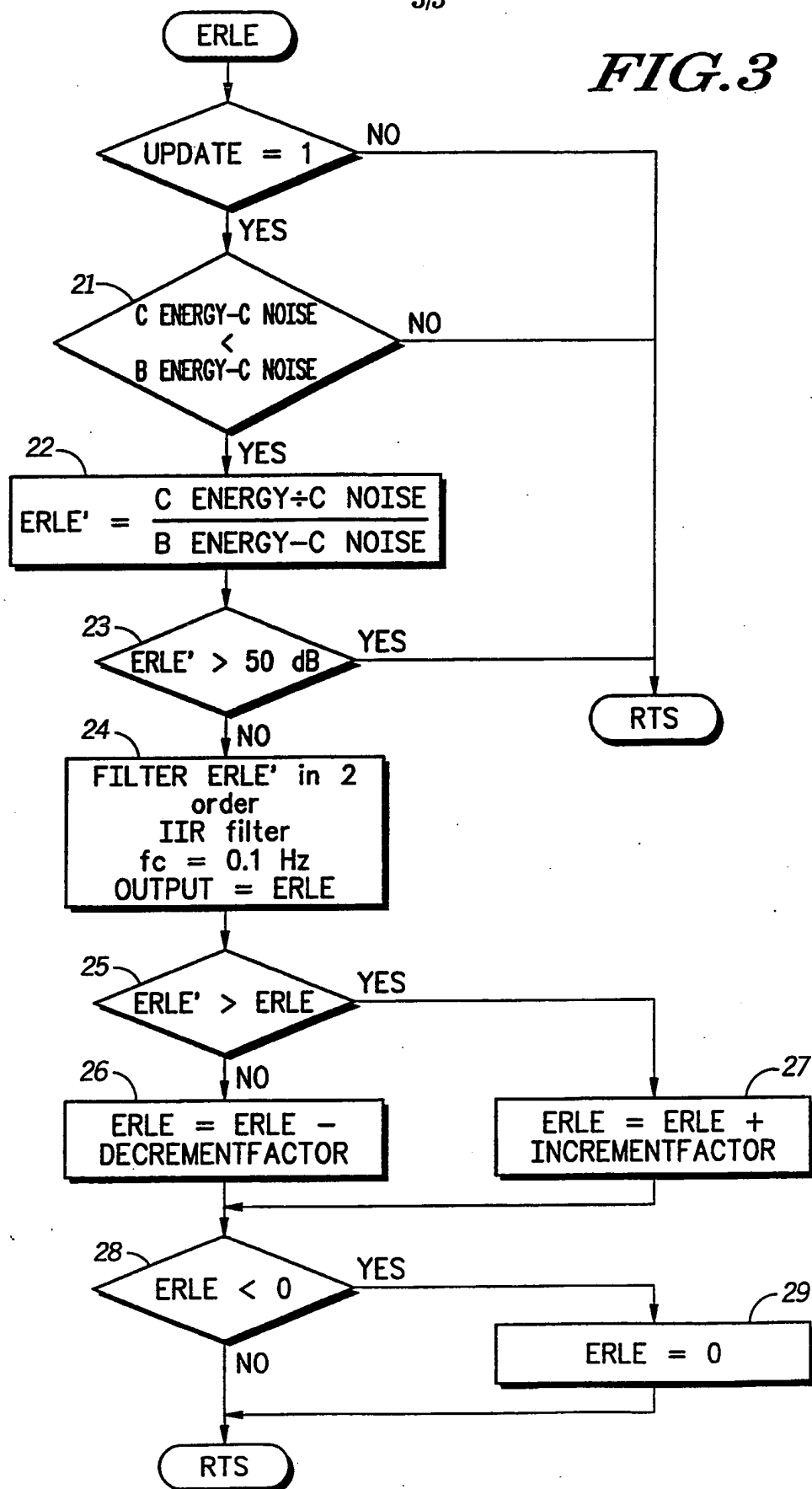


**FIG. 1**  
ECHOCANCELLER WITH AVSA

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*FIG. 2*

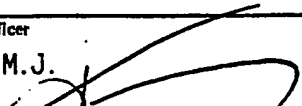
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*FIG.3*

## INTERNATIONAL SEARCH REPORT

PCT/EP 91/01130

International Application No

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (If several classification symbols apply, indicate all) <sup>6</sup>		
According to International Patent Classification (IPC) or to both National Classification and IPC: Int.Cl. 5      H04M9/08 ;      H04B3/23		
<b>II. FIELDS SEARCHED</b>		
Minimum Documentation Searched <sup>7</sup>		
Classification System	Classification Symbols	
Int.Cl. 5	H04M ;      H04B ;      H04Q	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched <sup>8</sup>		
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT<sup>9</sup></b>		
Category <sup>10</sup>	Citation of Document, <sup>11</sup> with Indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
X	PROCEEDINGS OF EUSIPCO-88 - FOURTH EUROPEAN SIGNAL PROCESSING CONFERENCE vol. 2, September 5, 1988, GRENoble (FR) pages 495 - 498; W.ARMBrUSTER: 'High Quality Hands-free Telephony using Voice Switching optimised with Ech o Cancellation ' see page 496, right column, line 1 - page 498, left column, line 4 ---	1,2,5
X	EP,A,282 393 (CONNAN) September 14, 1988 see column 1, line 56 - column 2, line 29 ---	1
A	GB,A,2 125 657 (UNITED NETWORKS) March 7, 1984 see page 1, line 104 - page 2, line 28 ---	1,2,4-6
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<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
12 SEPTEMBER 1991	26.09.91	
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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category °	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	<p>PATENT ABSTRACTS OF JAPAN vol. 9, no. 169 (E-328)(1892) July 13, 1985 &amp; JP-A-60 41 849 (TOSHIBA ) March 5, 1985 see the whole document</p> <p>---</p>	1

# ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

EP 9101130  
SA 48290

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.  
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP-A-282393	14-09-88	FR-A- 2612029 JP-A- 63299436 US-A- 4984265	09-09-88 06-12-88 08-01-91
GB-A-2125657	07-03-84	None	